Chapter 11

11. Visual Search Patterns

Almost all search and rescue missions are concluded by visual searches of the most probable areas once good information has been received from electronic searches, SARSATs, or other sources. This chapter will cover visual search patterns, some advantages and disadvantages of each, and some of the factors that help determine the type of search pattern you should use. The observer and mission pilot must carefully assess several important factors and their effects that go into the planning phase of a search operation.

Because of the accuracy and reliability of the present Global Positioning System and GPS receivers, CAP aircrews are now able to navigate and fly search patterns with unprecedented effectiveness and ease. The GPS has become the primary instrument for CAP air missions, and it is vital that pilots and observers know how to use the GPS to fly these patterns.

However, observers must also be familiar with the other navigational instruments onboard CAP aircraft. These instruments complement the GPS and serve as backups in case of GPS receiver problems.

Note that this section deals with navigational instruments as a *mission* tool and is not concerned with the FAA rules and restrictions on GPS use under the Federal Aviation Regulations. Under these rules, CAP GPS receivers are for VFR use only and are not certified for instrument flight; the FAA certified navigational instruments are the ADF, VOR, and DME. It is the responsibility of the pilot-in-command to adhere to all applicable FAA and CAP rules and regulations pertaining to the use of these instruments.

OBJECTIVES:

1. Plan and describe how to fly a route search. {O & P; 11.2}
2. Plan and describe how to fly a parallel search. {O & P; 11.3}
3. Plan and describe how to fly a creeping line search. {O & P; 11.4}
4. Plan and describe how to fly an expanding square search. {O & P; 11.5}
5. Discuss how to plan and fly a sector search. {O & P; 11.6}
6. Discuss how to plan and fly a basic contour search. {O & P; 11.7}

NOTE: Scanners need a basic knowledge of the search patterns.

11.1 Planning Search Patterns

Before missions are launched, the briefing officer provides pilots and crewmembers with information designating the routes to and from the search area, and the types of search patterns to be used upon entering the search area. Mission observers, in assisting navigation, should be familiar with each type of search pattern. The following descriptions are directed primarily toward a single aircraft search, and will cover track line, parallel, creeping line, expanding square, sector and contour search patterns.

The majority of CAP aircraft are Cessna 172s that only carry three crewmembers, so *we assume that the crew consists of a pilot, an observer in the right front seat, and a single scanner in the rear seat*. We assume that the observer will be looking out the right side of the aircraft while the scanner covers the left side; therefore the observer's primary duty during the search is to be a scanner. If a larger aircraft is used there may be two scanners in the rear seat.

The observer (as mission commander) must be aware of how many scanners will be on board in order to assign which side of the aircraft they should scan. *Planning and executing a search pattern with only one scanner on board is quite different from one where you have two scanners*. Likewise, having an observer and two scanners on board will allow the observer to spend more time assisting the pilot without seriously decreasing search effectiveness.

When you are planning and flying search patterns, always perform a *stupid check* -- as in "Hey! Wait a minute. This is stupid." Use this to see if your headings, waypoint positions, lat/long coordinates and distances look sensible. At a minimum, perform this check after you finish planning, when you start your pattern, and periodically thereafter. For example, you've just entered a set of lat/long coordinates into the GPS and turned to the heading shown on the GPS. You know the coordinates represent a lake southwest of your position, so check the heading indicator to see you're actually traveling in a southwesterly direction. Or, you know the lake is approximately 25 nm away; check the distance indicated on the GPS! You'd be surprised how many mistakes this method will catch.

In the following discussions of the parallel line, creeping line and expanding square search patterns, examples (worksheets) are given to aid in pre-planning each pattern. The examples are designed for aircraft using the older (non-moving map) GPS units, but the information you will need to set up the search pattern in the GX55 is included on the worksheets.

In both cases (old versus new GPS), pre-planning (plotting) your search pattern results in the most effective search. Pre-planning sets the details of the sortie in your mind and makes entering your data (correctly) into the GPS much easier. This allows the pilot and observer to concentrate on their primary task by minimizing navaid setup time and reducing confusion. The worksheets used in our examples (and included in the *Flight Guide*, Attachment 2) are just one method you can use to pre-plan your search patterns.

11.2 Track crawl (route) search

The planning section chief will normally use the track line (route) search pattern when an aircraft has disappeared without a trace. This search pattern is based on the assumption that the missing aircraft has crashed or made a forced landing on or near its intended track (route). It is assumed that detection may be aided by survivor signals or by electronic means. The track line pattern is also used for night searches (in suitable weather). A search aircraft using the track line pattern flies a rapid and reasonably thorough coverage on either side of the missing aircraft's intended track.

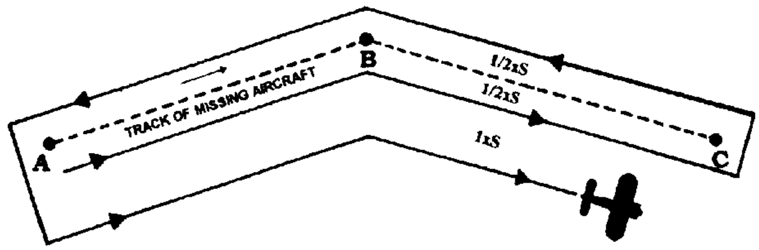


Figure 11-1

Figure 11-1 illustrates the track crawl search pattern. Search altitude for the track line pattern usually ranges from 1000 feet above ground level (AGL) to 2000 feet AGL for day searches, while night searches range 2000 to 3000 feet AGL (either depending upon light conditions and visibility). Lat/long coordinates for turns are determined and then entered into the GPS as waypoints, which may then be compiled into a flight plan.

The search crew begins by flying parallel to the missing aircraft's intended course line, using the track spacing (labeled “S” in Figure 11-1) determined by the incident commander or planning section chief. On the first pass, recommended spacing may be one-half that to be flown on successive passes. Flying one-half “S” track spacing in the area where the search objective is most likely to be found can increase search coverage. You may use a worksheet to draw the route and to log coordinates and distinctive features.

The GX55 has a function called "parallel track offset" that is very handy for route searches. This function allows you to create a parallel course that is offset to the left or right (up to 20 nm) of your current flight plan. This function can also be useful on when you wish to search a 'corridor' of airspace.

11.3 Parallel track or parallel sweep

The parallel track (sweep) procedure is normally used when one or more of the following conditions exist:

- The search area is large and fairly level.
- Only the approximate location of the target is known.
- Uniform coverage is desired.

The aircraft proceeds to a corner of the search area and flies at the assigned altitude, sweeping the area maintaining parallel tracks. The first track is at a distance equal to one-half (1/2) track spacing (S) from the side of the area (Figure 11-2).

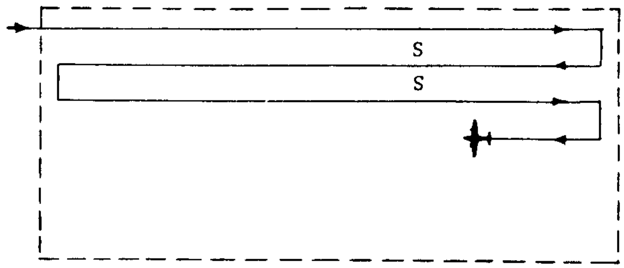


Figure 11-2

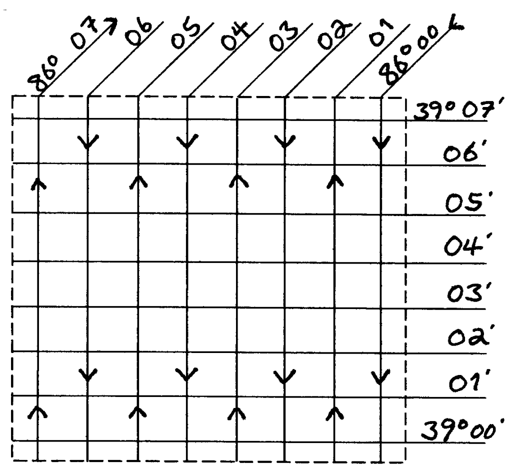
This type of search is used to search a grid. A worksheet (Figure 11-3) may be used to plan the search. You can use this to enter the latitudes and longitudes that define the entry point and bound the grid.

Grid Coordinates

SECTIONAL: STL N S GRID # 104 A B C D

ENTRY POINT: N 39°07.5' W 86°00'

EXIT POINT: N 39°07.5' W 86°07'



NAVIGATIONAL AIDS

	IDENTIFIER	FREQUENCY	RADIAL
1.	OOM	110.2	090°
2.	ABB	112.4	330°

Figure 11-3

In the example, you will be searching STL Grid #104-D, which is a quarter-grid measuring 7.5° x 7.5°. Plot the grid's coordinates and draw the pattern starting at the entry point (northeast corner); include track spacing (one nm) and the direction of the legs (north/south). You will enter the entry point coordinates as a waypoint (N 39° 07´ W 86° 00´; northeast corner). As you fly to the entry point, set up at search altitude and speed about 3-5 miles out. Then fly the pattern using the GPS' continuous latitude/longitude display (e.g., present position). Remember, latitude increases as you go north; longitude increases as you go west.

Even though you are using the GPS lat/long display, it's still helpful to note your headings for the legs (in the example, north and south). Once you have flown a couple of legs you will have two headings that you can shoot for that will correct for any wind; it's easier to use the heading indicator as your primary indicator and check your accuracy with the GPS. [Note: if you're not using your VOR heads, set the top OBS with one heading (e.g., north) and the lower OBS to the other heading -- use all available equipment.]

Also, always enter relevant VOR cross-radials onto your worksheet; use them as a backup and to verify important positions.

Latitude, Longitude, and Distance

For training purposes, we assume that "one minute = one nautical mile."

In the continental U.S., one minute of latitude is equivalent to 1.0018 nm; for our purposes you can assume that if you fly one minute of latitude (north/south) you are covering one nm -- very handy for flying 1-nm east/west track spacing with 'present position' displayed on the GPS.

Longitude isn't so clean: in Washington state one minute of longitude may be equivalent to 0.6572 nm, in the central parts of the country its 0.7695 nm, and in Florida it may be 0.9152 nm. This means that to fly a north/south 1-nm leg means flying anywhere from 1.5 to 1.1 minutes of longitude, depending on where you are in the country. This isn't hard to do, but for training we fly one-minute longitudinal legs even though it means flying less than 1-nm north/south track spacing). [To find the latitude/longitude/distance relationship for your area, go to http://jan.ucc.nau.edu/~cvm/latlongdist.php]

In the example above (Figure 11-3) you are flying a quarter-grid with north/south legs and one-mile track spacing. The aircraft enters the grid at the northeast corner and flies a constant longitude (W 86º 00´) southbound until the pilot sees the latitude decrease to where she will begin her turn to the east (e.g., N 39º 00´). When she completes the 180º turn she should be flying a constant longitude northbound, offset one mile east of the first leg (W 86º 01´; remember, for training we are using "one minute = one nautical mile"). The pilot will continue up this longitude line, watching the latitude increase until it is time to begin the next turn to the east (e.g., N 39º 07´). This process will be repeated until the search is completed.

Note: The turns in the example above will take the aircraft out of the grid north and south; make sure no other aircraft are assigned to the grids north or south of yours. If aircraft are assigned to adjacent grids, make sure you complete your turns *inside* your grid.

GX-55

All the data you need set up this search pattern in the GX55 is on the worksheet:

- Type of Grid and Sectional (US grid, STL).
- Type of pattern (Parallel Line).
- Grid (104D2, where '2' indicates entering the northeast corner of D quadrant *).
- Spacing (1 nm).
- Direction of Travel (N/S).

* The GX-55 identifies the corners of quadrants by numbers: 1 = enter the NW corner; 2 = NE corner; 3 = SE corner; and 4 = SW corner. In our example you would enter "104D*2*."

Note: If you wish, record this data separately (e.g., a list or table) to make it even easier to enter into the GX-55. The example, above, and the other examples that follow are listed in the sequence that you enter them into the GX-55.

11.4 Creeping line search

The creeping line search pattern is similar to the parallel patterns. The parallel pattern search legs are aligned with the major, or longer, axis of the rectangular search areas, whereas the search legs of the creeping line pattern are aligned with the minor or shorter axis of rectangular search areas. Figure 11-4 shows the layout of this search pattern. The planning section chief uses the creeping line pattern when:

- The search area is narrow, long, and fairly level.
- The probable location of the target is thought to be on either side of the search track within two points.
- There is a need for immediate coverage of one end of the search area.

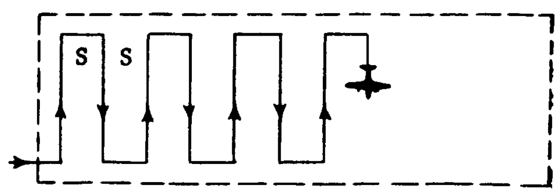


Figure 11-4

This coverage is followed immediately by rapid advancement of successive search legs along the line. Rectangular and elongated are the two forms of the creeping line pattern. For each form, the starting point is located one-half search track spacing inside the corner of the search area.

Successive long search legs use track spacing assigned by the incident commander or planning section chief, while the short legs may be flown to within one-half that spacing of the search area's edge.

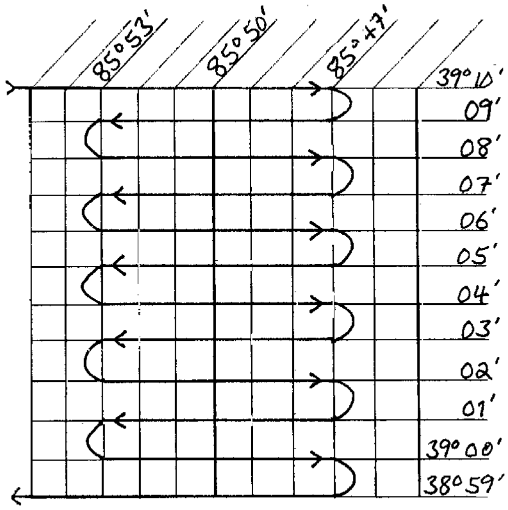
A worksheet (Figure 11-4a) may be used to plan the search. Assume you will be searching along Highway 31 between Columbus and Seymour, starting at the intersection with Highway 9 and ending at the intersection with Highway 50 (just east of Seymour). Draw the pattern starting at the entry point (intersection of Hwy 31/9, Columbus); include track spacing (one nm) and make each leg extend three nm east and west of the highway. You will enter the entry point coordinates as a waypoint (N 39º 10´ W 85º 53´). As you fly to the entry point, set up search altitude and airspeed three to five miles out, then fly the pattern using the GPS' continuous lat/long display. In this example, you will initially fly a constant latitude line of N 39º 10´ until you reach W 85º 47´ where you will turn right 180º and stabilize on a constant latitude line of N 39º 09´; repeat this process until the search is completed.

Creeping Line Coordinates

SECTIONAL: STL (N) S GRID # ________ A B C D

ENTRY POINT: N 39° 10' W 85° 53'

EXIT POINT: N 38° 59' W 85° 53'



NAVIGATIONAL AIDS

	IDENTIFIER	FREQUENCY	RADIAL
	OOM	110.2	090°
2.	SHB	112.0	181°
3.	OOM	110.2	097°

Figure 11-4a

If the route is along a cardinal heading such as the highway in Figure 11-4a, then the pilot will simply fly the creeping line using continuously displayed latitude and longitude. However, when the route is not a straight line aligned with a cardinal heading, another method may be used to fly a creeping line search pattern (Figure 11-4b).

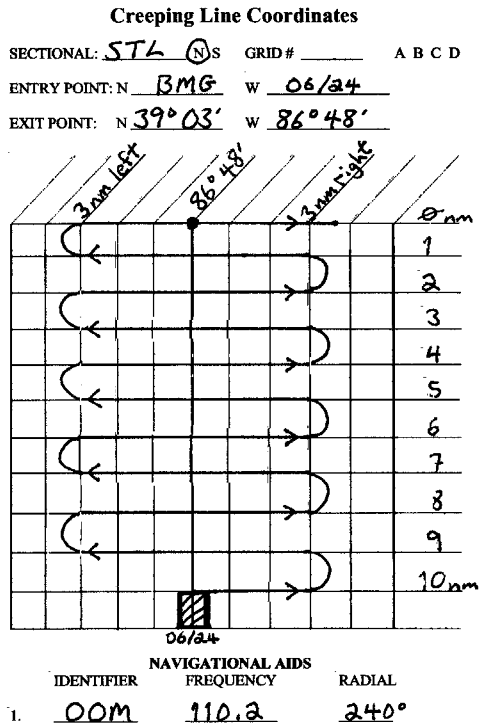


Figure 11-4b

Assume that the aircraft will be flying a creeping line for ten miles southwest along an (imaginary) extended runway centerline (06/24 at BMG), and it is desired to fly three miles to either side of the extended runway centerline with one-mile track spacing. Draw the pattern starting at the entry point (Runway 06, BMG); include track spacing (one nm) and make each leg extend three miles either side of the extended centerline. In the right column enter the distance from the waypoint for each leg, starting at ten miles and counting down. Enter the exit point's lat/long (N 39º 03´ W 86º 48´; ten miles southwest of the end of runway 06) in the GPS as a waypoint.

Enter the airport (BMG) as a destination and fly to it. Set the aircraft up at search altitude and airspeed three to five miles from the airport. Select the waypoint you created as your new destination.

When you fly over the end of Runway 06, zero (reset) the CDI display on the GPS. This sets up a *route* in the GPS that represents a direct line between the entry (end of runway 06) and exit points. The GPS should show ten miles to the destination, and the CDI will be centered.

Use the distance to the destination to establish and maintain one-mile track spacing; use the CDI deviation indication to indicate when you have gone three miles to either side of the line.

The pilot begins his first turn, for example to the right. By maintaining the distance from the destination constant (e.g., ten miles) the aircraft will be flying *almost* perpendicular to the extended runway centerline. Watch the CDI, which will begin showing that the aircraft is deviating from the intended route to the right. When the aircraft has deviated by almost three miles (the length of your right leg) the pilot will begin a turn to the left. The turn will be completed so that the aircraft will now be flying in the opposite direction at a distance of nine miles from the destination (the one-mile track spacing).

Now watch the CDI begin to return to center while maintaining a constant nine-mile distance from the destination. Continue as the CDI begins to deviate to the left, and the next turn (to the right) will begin as you approach a three-mile deviation. Continue this pattern until you have completed your search.

Note: By using this technique you will actually be flying arcs instead of the usual squared (rectangular) legs. This is of little concern since the purpose is to cover the entire search area in a methodical manner.

This method is very handy when you are assigned a creeping line while airborne. It's easy to plan, set up and perform once you have mastered the technique.

You can also fly this pattern along a Victor airway. You can fly a similar pattern using the DME; it will be like flying a series of DME arcs.

This method can also be used along a winding river or a road, but the pilot must plan a line that roughly bisects the winding route and then vary the length of the legs as conditions warrant on the ground below.

GX-55

The creeping line is similar to the parallel line pattern, but the starting point is a selected waypoint rather than a grid. The pattern will straddle the center of your flight plan.

All the data you need set up this search pattern in the GX-55 is on the worksheet:

- Type of Grid and Sectional (US grid, STL).
- Type of pattern (Creeping Line).
- Starting Waypoint (the airport, BMG).
- Spacing (1 nm).
- Direction of Travel (the runway heading, 060º).
- Leg Length (3 nm *).
- Start Side (Right).

* 9.9 nm is the longest leg length you can select on the GX-55.

11.5 Expanding square search

The planning section chief normally uses the expanding square search pattern when the search area is small (normally, areas less than 20 miles square), and the position of the survivors is known within close limits. This pattern begins at an initially reported position and expands outward in concentric squares. If error is expected in locating the reported position, or if the target were moving, the square pattern may be modified to an expanding rectangle with the longer legs running in the direction of the target's reported, or probable, movement.

If the results of the first square search of an area are negative, the search unit can use the same pattern to cover the area more thoroughly. The second search of the area should begin at the same point as the first search; however, the first leg of the second search is flown diagonally to the first leg of the first search. Consequently, the entire second search diagonally overlays the first one. The bold, unbroken line in Figure 11-5 illustrates the first search, while the dashed line represents the second search. Track spacing indicated in Figure 11-5 is "cumulative," showing the total width of the search pattern at a given point on that leg. Actual distance on a given leg from the preceding leg on the same side of the pattern is still only one "S," the value determined by the incident commander or planning section chief.

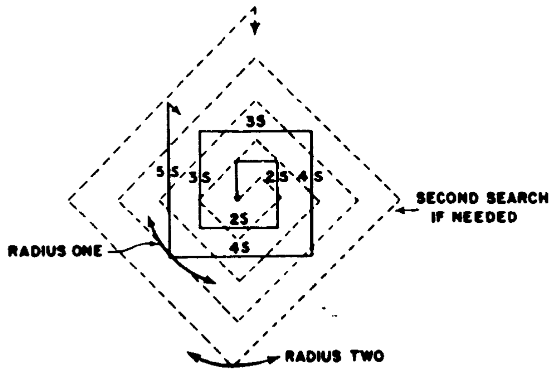


Figure 11-5

The GPS is used because this pattern requires precise navigation and is affected by wind drift. Even using the GPS, it is helpful to orient the expanding square pattern along the cardinal headings to reduce confusion during turns.

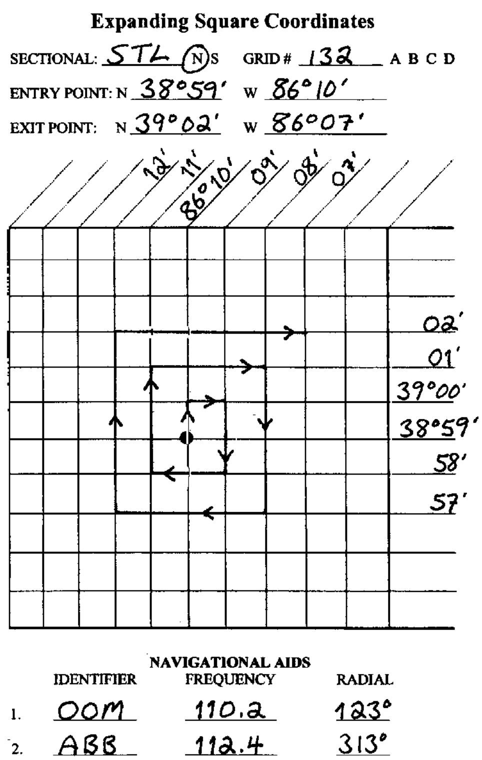


Figure 11-5a

Fill the worksheet (Figure 11-5a) with the lat/longs that describe the expanding square. Starting at the entry point (a 483′ AGL tower approximately eight nm west of Seymour), draw the square by going one mile north, then one mile east, then two miles south, and so on. You set it up this way because it is best to fly the square by first flying due north and then making all subsequent turns to the right; right turns are used because they allow the observer and scanner(s) to see the ground during the turns. You use cardinal headings because they are easiest for the pilot to fly. Length and width of the pattern may be modified to suit the requirements and conditions of the individual search.

Enter the lat/long of the starting point (N 38º 59´ W 86º 10´) into the GPS and save it as a waypoint. Select the waypoint and fly to it, maneuvering to approach from the south at about three to five miles out. Set altitude and airspeed so the aircraft is stable and the pilot will be ready to concentrate on flying the pattern precisely. Fly the pattern using the heading indicator and continuously displayed latitude and longitude on the GPS.

Note: If the aircraft doesn't have an operable GPS the first leg should be flown directly into or directly with the wind. Every other leg will thus be affected by the wind in a relatively consistent manner.

<u>GX-55</u>

The expanding square will radiate from a starting waypoint according to the spacing between lines and at an angle selected by you.

All the data you need set up this search pattern in the GX-55 is on the worksheet:

- Type of Grid and Sectional (US grid, STL).
- Type of pattern (Expanding Square).
- Starting Waypoint (483´ AGL tower approximately eight nm west of Seymour, N 38º 59´ W 86º 10´).
- Spacing (1 nm).
- Direction of Travel (due north, 000º).

11.6 Sector search

The sector search is another visual search pattern that can be used after the approximate location of the target is known. This pattern should be planned on the ground because it involves multiple headings and precise leg lengths. The pilot will fly over the suspected location and out far enough to make a turn, fly a leg that is equal to the maximum track spacing, then turn back to fly over the point again. This pattern continues until the point has been crossed from all the angles as shown in Figure 11-6.

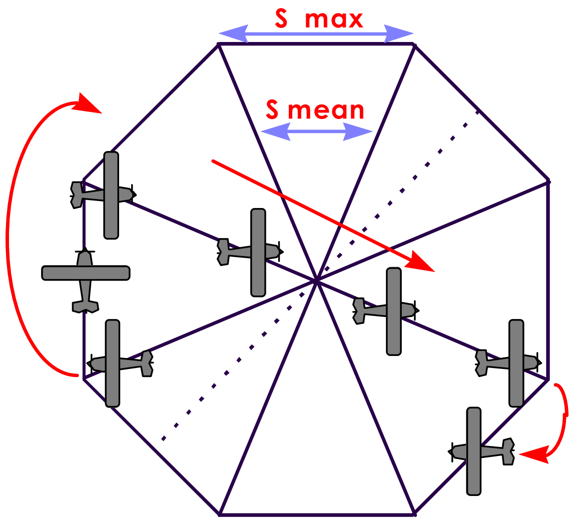


Figure 11-6

The sector search has several advantages:

- It provides concentrated coverage near the center of the search area
- It is easier to fly than the expanding square pattern
- It provides the opportunity to view the suspected area from many angles, so terrain and lighting problems can be minimized.

11.7 Contour search

As previously discussed, flying in mountainous terrain requires special training (i.e., *Mountain Fury*). This search pattern (Figure 11-7) is presented for information only, but it may be effectively used for hills and other similar terrain that is not considered high altitude terrain.

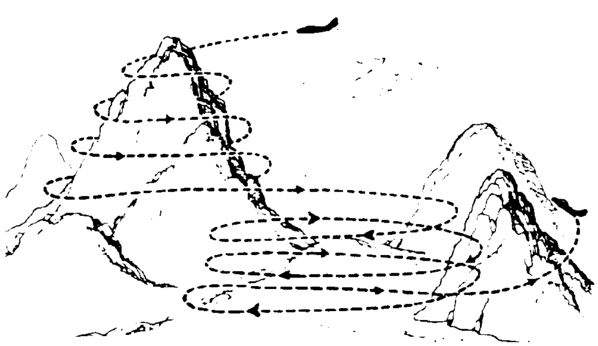


Figure 11-7

The contour search pattern is best adapted to searches over mountainous or hilly terrain. When using this pattern, the pilot initiates the search at the highest peak over the terrain. As in the case of mountains, the pilot flies the aircraft around the highest peak "tucked in" closely to the mountainside. As each contour circuit is completed the pilot lowers the search altitude, usually by 500 feet. While descending to a lower altitude, the pilot turns the aircraft 360º in the direction opposite to the search pattern.

As you may have already gathered, the contour search pattern can be dangerous. The following must be keep in mind before and during a contour search:

- First and foremost, the pilot and crew must be qualified for mountain flying *and proficient*.
- The crew should be experienced in flying contour searches, well briefed on the mission procedures, and have accurate, large-scale maps indicating the contour lines of the terrain.
- Weather conditions should be good with respect to visibility.
- Wind gusts should be minimal to nonexistent.
- The search aircraft should be maneuverable with a steep climbing rate and capable of making small turning circles.
- The search should be started above the highest peak of the terrain.

Valleys and canyons also pose problems during contour searches. The search crew should highlight or mark all valleys on their maps that pose possible hazards to contour searching. If the search aircraft cannot turn around or climb out of a certain valley or canyon, the crew should mark the area and exercise extreme caution during the search. If required to fly down narrow canyons, fly down the canyon with the mouth always yielding a safe way out.

As an observer on a contour search mission you should keep an accurate record of the areas searched. Since some areas will be shrouded in fog or clouds, you will have to search those areas when weather conditions permit. One method of keeping records during contour searches is to shade searched areas on the map. The areas that you leave unshaded are the areas that you have not searched.

Valleys or canyons can also pose hazards during contour searches. If any crew member senses that further flight may put the search airplane in a situation where it can neither turn around nor climb out of a valley or canyon, the aircraft must not proceed any further. The crew should exercise extreme caution, mark the area on the chart, and report the problem to the planning section chief or debriefing officer. If required to fly through canyons, fly *down* the canyon with the canyon mouth always yielding a safe way out.

The search crew should also highlight or mark all valleys on their maps that pose possible hazards to a contour search. Crewmembers must stay alert for wires and power lines that may cross a canyon or valley significantly above its floor. The observer will later report the hazards to the mission debriefer, so that he or she may brief other crews of the hazards.

11.8 Other SAR-related GPS Features

There is no substitute for thoroughly studying your GPS users guide. However, we will highlight some features of the GPS (both the old type and the GX-55) that are important to our missions (GX-55 SAR operations are covered in Attachment 2).

User guides can often be found on the manufacturer's web site. For example, the GX-55 user's guide is located at www.upsat.com/dwnlds/gxdoc/gx-user-r3a.pdf. Also, several CAP Wings have specially developed guides that are very useful; a good example is the *GX55MiniGuide* that can be found at es.mnwg.cap.gov/es/training.

11.8.1 Display Current Position

Select the AUX (Auxiliary) page.

<u>GX-55</u>

From the NAV (Navigation) screen, turn the large knob until "GPS Position" is displayed. [Note: PDOP (Position Dilution of Precision) is also displayed, and it is based on the geometry of the satellites used in the position solution. A lower number is a better value than a large one; that is, a PDOP of 3 indicates a more reliable position fix than a value of 7.]

11.8.2 Create a User Waypoint

In the WPT (Waypoint) mode turn to "Add User Waypoint" and press ENT. Enter an identifier and press ENT, then enter the latitude and longitude and press ENT.

<u>GX-55</u>

From the DB (Database) screen, turn the large knob until "Create User Waypoint by Lat/Lon" is displayed and press ENTER. Use the large and small knobs to enter the desired latitude and longitude. [Note: the large knob moves the flashing cursor forwards or backwards; the small knob selects individual characters or numbers at the flashing cursor.] Press ENTER to accept and save the user waypoint (or you can press NAV to abort the procedure).

You can also create a user waypoint set to a US Grid coordinate, which allows you to fly directly to the corner of a grid or quadrant (or use it in a flight plan). From the DB screen, turn the large knob until "Create User Waypoint by US Grid" is displayed and press ENTER. Use the large and small knobs to enter the desired grid identifier. Press ENTER to accept and save the waypoint

11.8.3 Save Current Position as a User Waypoint

Press the HLD pushbutton captures present lat/long and stores it in the user waypoint memory under the name "HLDxx," where 'xx' is a number between 00 and 99. You can then rename the waypoint. [Note: Under some settings you must push the HLD pushbutton twice to store the waypoint.]

<u>GX-55</u>

From the DB (Database) screen, turn the large knob until "Create User Waypoint by Lat/Lon" is displayed and press ENTER. The position (lat/long) of the GPS at the moment you push ENTER is set as a user waypoint.

From the SAR Map page, pressing the "Mark" smart key saves present position and brings up the user waypoint screen; you can change the name and the Lat/Long using the large and small knobs. Pressing ENTER will save the waypoint. [The very first time this feature is used, the position is assigned a default number, "SAR000". Subsequent saves are automatically given sequential numbers (e.g., SAR001 and SAR002); they can be recalled, edited and deleted but not overwritten.]

11.8.4 Recall a User Waypoint

User waypoints can be recalled from the Navigation or Flight Plan modes.

GX-55

From the DB (Database) screen, turn the large knob until the "Access Database" screen is displayed and press ENTER. Turn the small knob until USER is displayed, and then use the large and small knobs to enter characters of the user waypoint.